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Gallagher et al.

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(54) **METHOD AND SYSTEM FOR WIFI COMMUNICATION UTILIZING FULL SPECTRUM CAPTURE**

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(22) Filed: **Apr. 12, 2013**

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Related U.S. Application Data

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(51) **Int. Cl.**
H04W 72/04 (2009.01)
H04W 16/02 (2009.01)

(52) **U.S. Cl.**
CPC ***H04W 72/04*** (2013.01); ***H04W 16/02*** (2013.01)

(58) **Field of Classification Search**
CPC H04W 72/04; H04W 16/02
See application file for complete search history.

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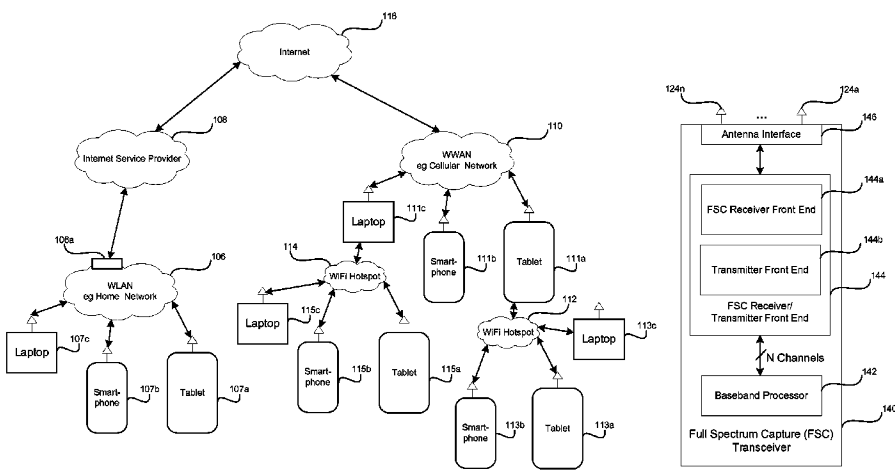
(57) **ABSTRACT**

A single receiver is operable to utilize full spectrum capture to capture signals over a wide spectrum comprising a plurality of WiFi frequency bands, extract one or more WiFi channels from said captured signals and aggregate a plurality of blocks of said WiFi channels to create one or more aggregated WiFi channels. The WiFi frequency bands include 2.4 GHz and 5 GHz WiFi frequency bands. A plurality of blocks of the WiFi channels may be aggregated from contiguous blocks of spectrum and/or non-contiguous blocks of spectrum in one or more of said plurality of WiFi frequency bands. One or more non-WiFi channels may be filtered out from the captured signals. One or more aggregated WiFi channels may be assigned to one or more WiFi enabled communication devices. At least a portion of the one or more aggregated WiFi channels may be dynamically assigned to one or more other WiFi enabled communication devices.

20 Claims, 7 Drawing Sheets



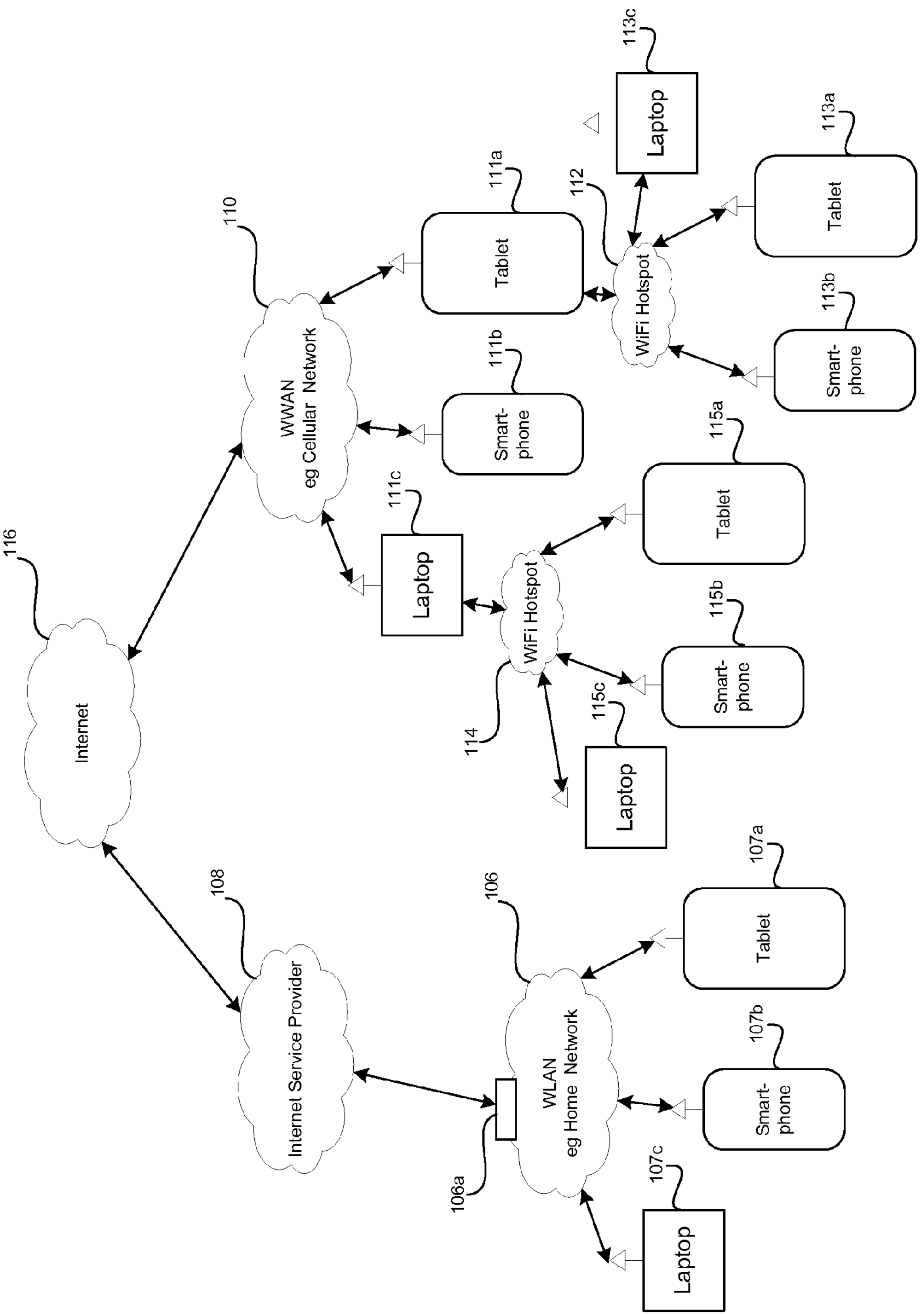

Internet
116
Internet Service Provider
108
WLAN
eg Home Network
106
106a
Tablet
107a
Smart-
phone
107b
Laptop
107c
WWAN
eg Cellular Network
110
Tablet
111a
Smart-
phone
111b
Laptop
111c
WiFi Hotspot
112
Tablet
113a
Smart-
phone
113b
Laptop
113c
WiFi Hotspot
114
Tablet
115a
Smart-
phone
115b
Laptop
115c

FIG. 1A

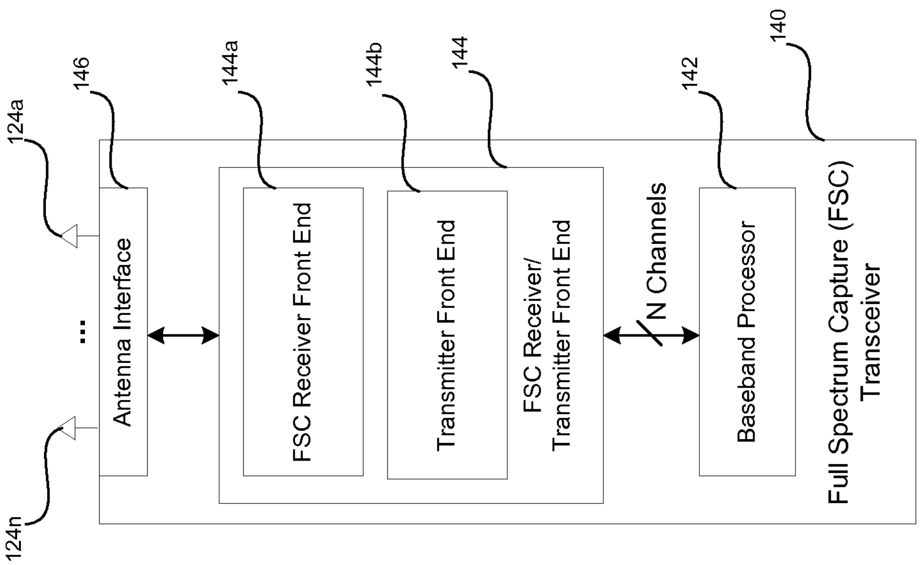

124a
124n
146
144a
144b
144
142
140
Antenna Interface
...
FSC Receiver Front End
Transmitter Front End
FSC Receiver/
Transmitter Front End
N Channels
Baseband Processor
Full Spectrum Capture (FSC)
Transceiver

FIG. 1B

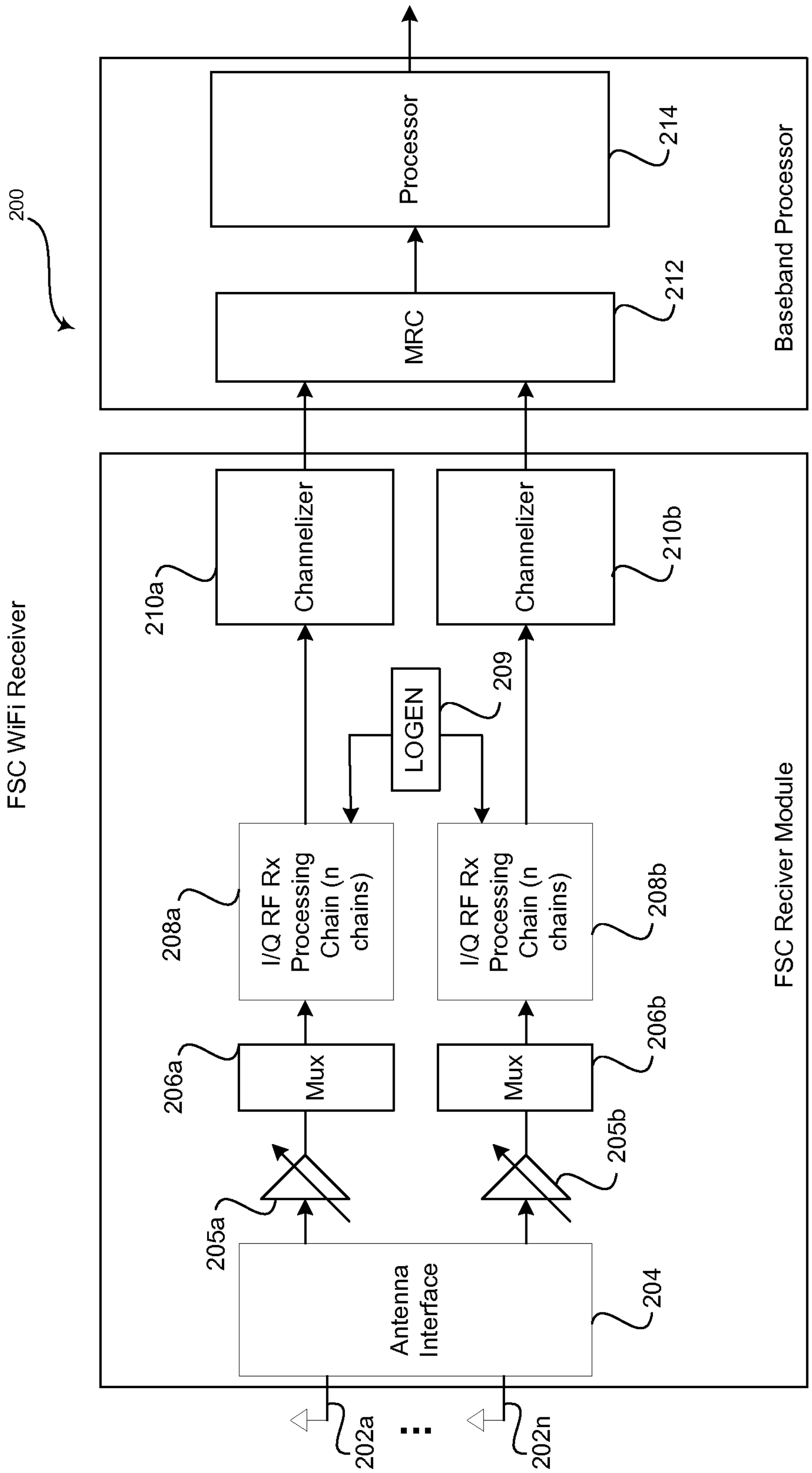

200
FSC WiFi Receiver
Baseband Processor
Processor
214
MRC
212
FSC Reciver Module
Channelizer
210a
Channelizer
210b
LOGEN
209
I/Q RF Rx Processing Chain (n chains)
208a
I/Q RF Rx Processing Chain (n chains)
208b
Mux
206a
Mux
206b
205a
205b
Antenna Interface
204
202a
...
202n

FIG. 2

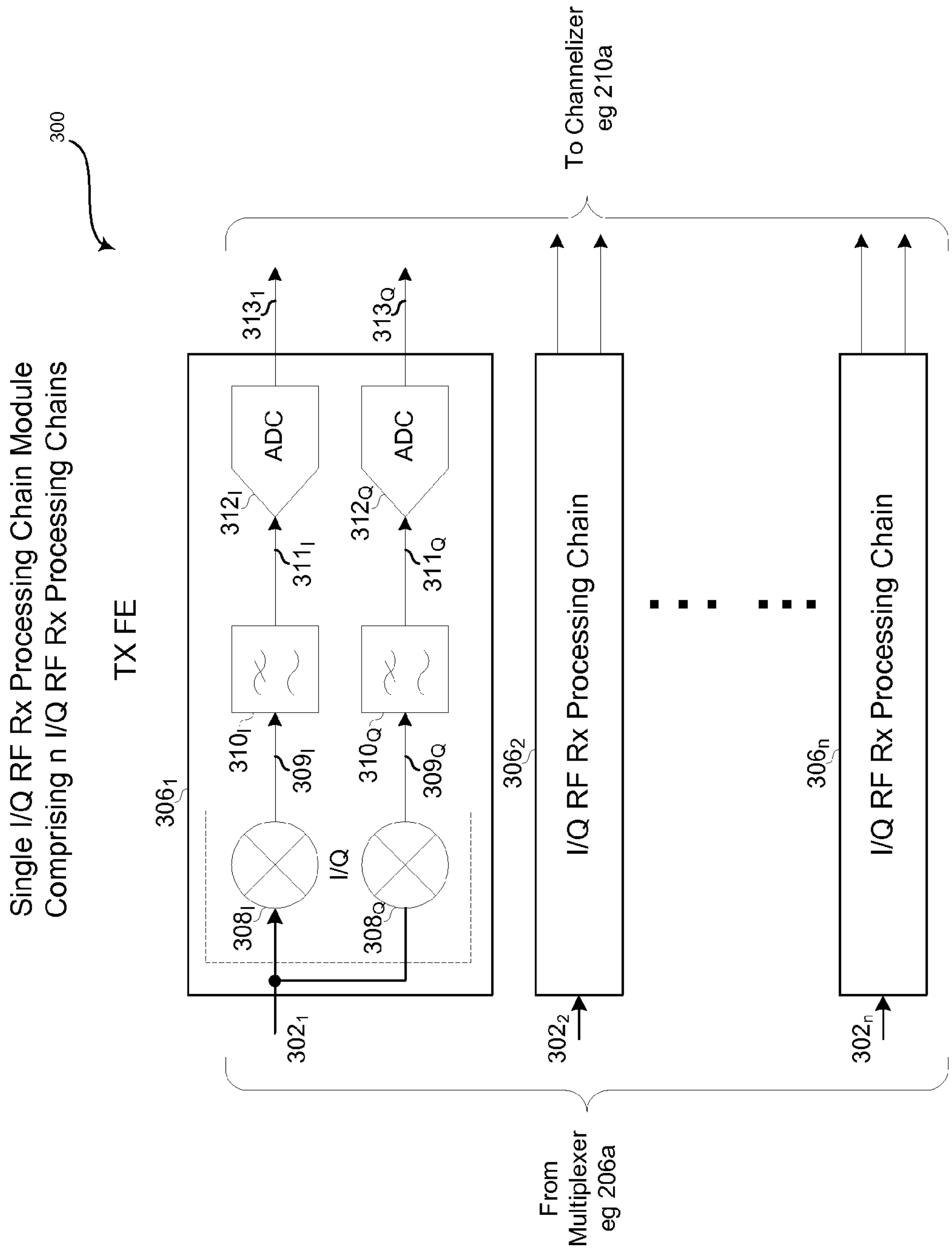

300
Single I/Q RF Rx Processing Chain Module
Comprising n I/Q RF Rx Processing Chains
TX FE
To Channelizer
eg 210a
From
Multiplexer
eg 206a
302_1
302_2
302_n
306_1
306_2
306_n
308_I
308_Q
I/Q
309_I
309_Q
310_I
310_Q
311_I
311_Q
312_I
312_Q
ADC
ADC
313_I
313_Q
I/Q RF Rx Processing Chain
I/Q RF Rx Processing Chain

FIG. 3

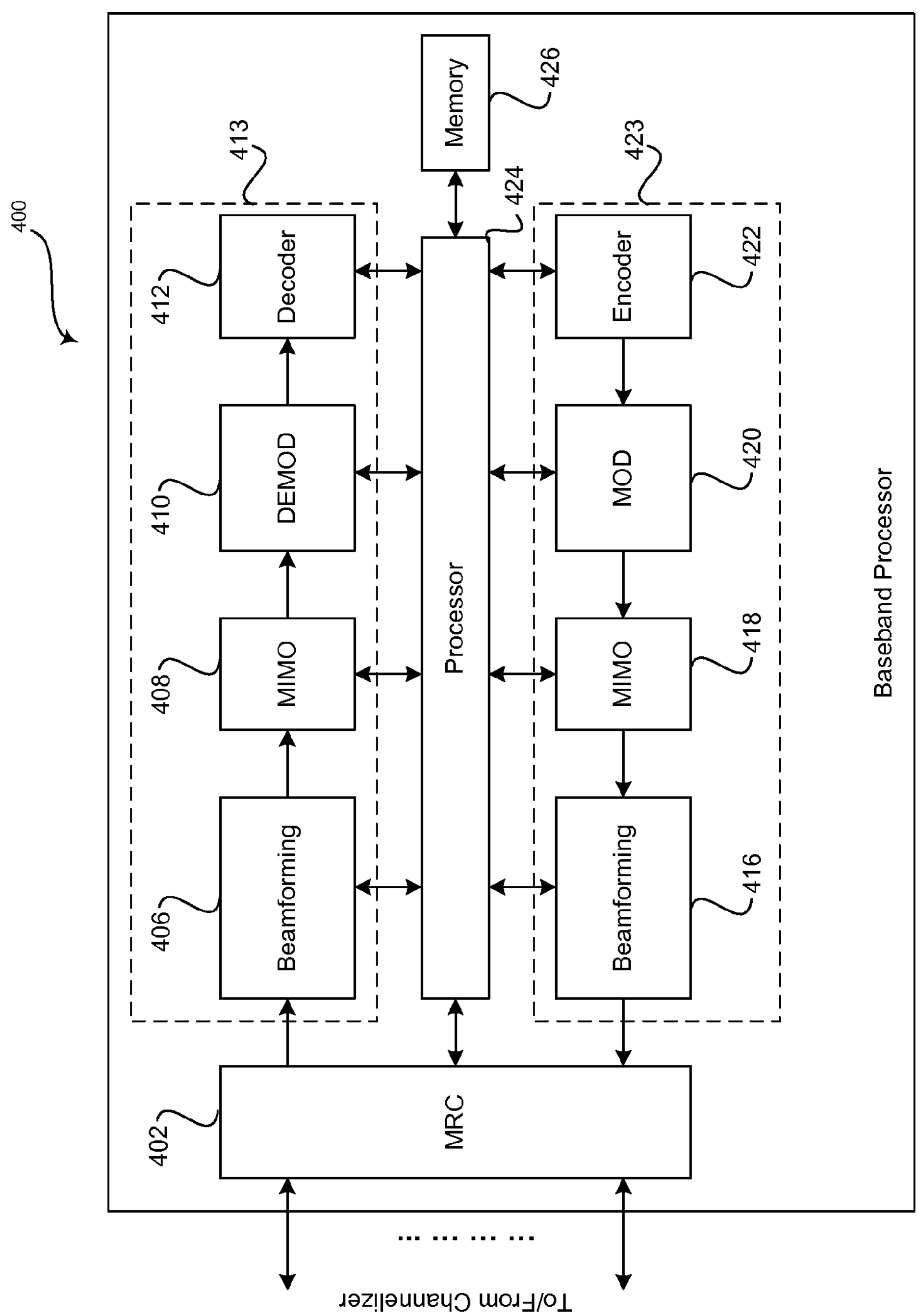
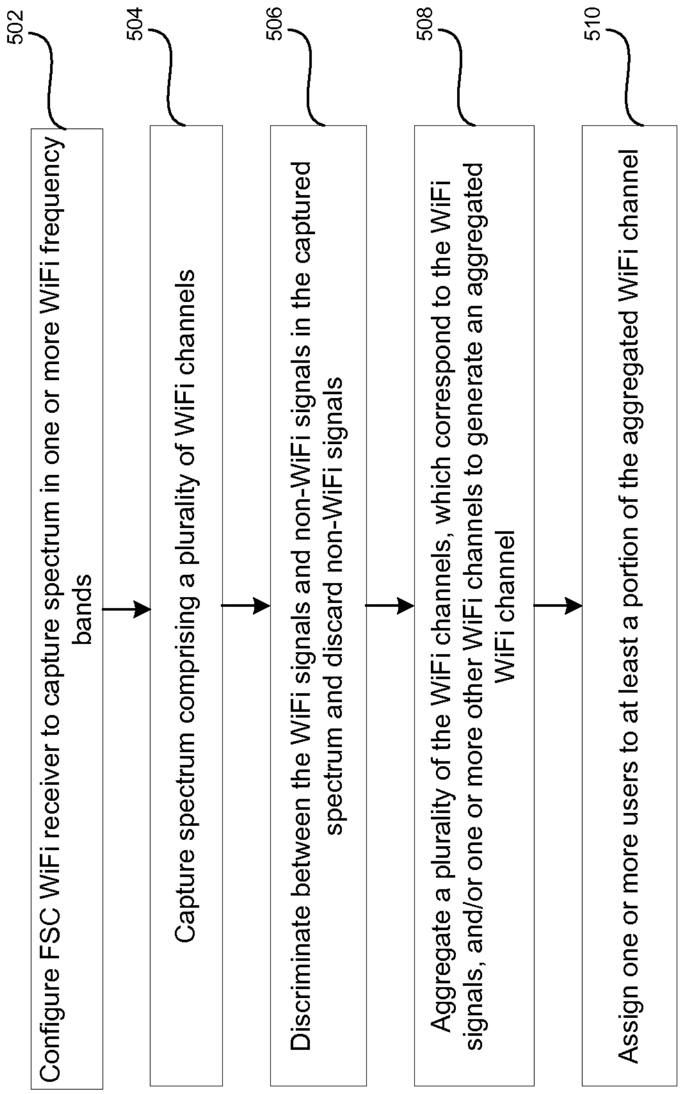

400
Baseband Processor
Memory
426
424
Processor
413
Decoder
412
DEMOD
410
MIMO
408
Beamforming
406
423
Encoder
422
MOD
420
MIMO
418
Beamforming
416
MRC
402
To/From Channelizer

FIG. 4



502
Configure FSC WiFi receiver to capture spectrum in one or more WiFi frequency bands
504
Capture spectrum comprising a plurality of WiFi channels
506
Discriminate between the WiFi signals and non-WiFi signals in the captured spectrum and discard non-WiFi signals
508
Aggregate a plurality of the WiFi channels, which correspond to the WiFi signals, and/or one or more other WiFi channels to generate an aggregated WiFi channel
510
Assign one or more users to at least a portion of the aggregated WiFi channel

FIG. 5

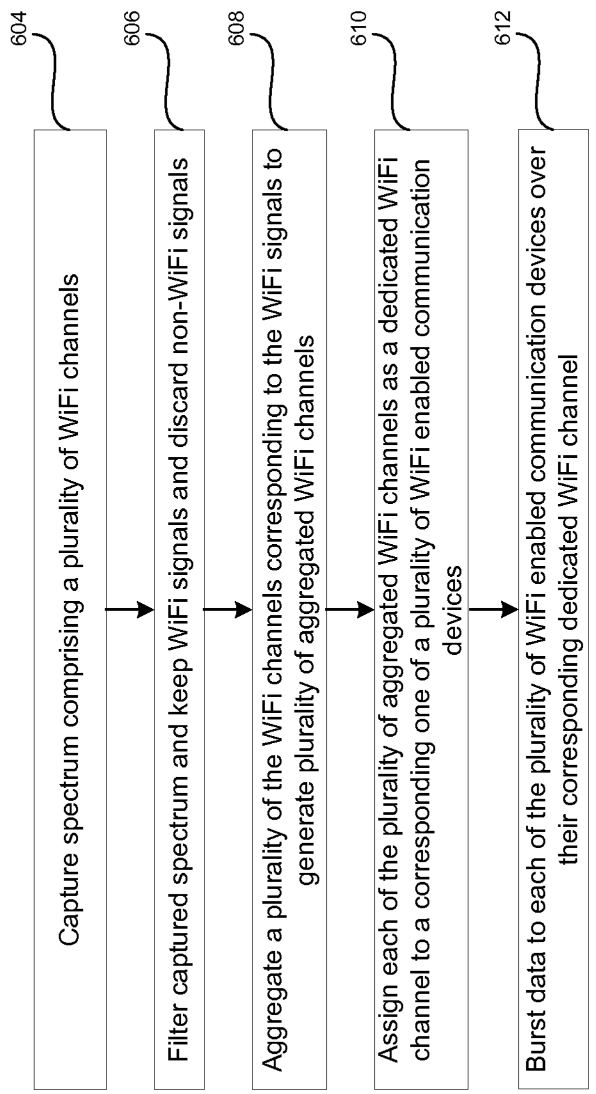

604
Capture spectrum comprising a plurality of WiFi channels
606
Filter captured spectrum and keep WiFi signals and discard non-WiFi signals
608
Aggregate a plurality of the WiFi channels corresponding to the WiFi signals to generate plurality of aggregated WiFi channels
610
Assign each of the plurality of aggregated WiFi channels as a dedicated WiFi channel to a corresponding one of a plurality of WiFi enabled communication devices
612
Burst data to each of the plurality of WiFi enabled communication devices over their corresponding dedicated WiFi channel

FIG. 6

METHOD AND SYSTEM FOR WIFI COMMUNICATION UTILIZING FULL SPECTRUM CAPTURE

CROSS-REFERENCE TO RELATED APPLICATIONS/INCORPORATION BY REFERENCE

This application makes reference to, claims priority to, and claims the benefit from U.S. Provisional Application Ser. No. 61/623,248, which was filed on Apr. 12, 2012.

This application also makes reference to:

U.S. Pat. No. 8,611,483 (application Ser. No. 13/485,003 filed on May 31, 2012), which issued on Dec. 17, 2013;

United States Publication Serial No. 2012/0163518 (application Ser. No. 13/336,451 filed on Dec. 23, 2011), which published on Jun. 28, 2012:

U.S. Pat. No. 8,792,008 (application Ser. No. 13/607,916 filed on Sep. 10, 2012), which issued on Jul. 29, 2014;

United States Publication Serial No. 2013/0268978 (application Ser. No. 13/857,776, which was filed on Apr. 5, 2013), which published on Oct. 10, 2013;

U.S. Pat. No. 9,125,185 (application Ser. No. 13/862,345, which was filed on Apr. 12, 2013), which issued on Sep. 2, 2015;

United States Publication Serial No. 2013/0272227 (application Ser. No. 13/862,336, which was filed on Apr. 12, 2013, which published on Oct. 17, 2013;

U.S. Pat. No. 8,725,104 (application Ser. No. 13/356,265, which was filed on Jan. 23, 2012) which issued on May 13, 2014; and

U.S. Pat. No. 8,010,070, (application Ser. No. 12/247,908, which was filed on Oct. 8, 2008), which issued on Aug. 30, 2011, discloses exemplary Low-Complexity Diversity Using Coarse FFT and Coarse Sub-band-wise Combining.

Each of the above referenced applications is hereby incorporated herein by reference in its entirety.

FIELD OF THE INVENTION

Certain embodiments of the invention relate to wireless communication. More specifically, certain embodiments of the invention relate to a method and system for WiFi communication utilizing full spectrum capture.

BACKGROUND OF THE INVENTION

WiFi Signals occupy bandwidth in two non-contiguous spectral bands in the 2.4 and 5 GHz regions of the frequency spectrum.

Further limitations and disadvantages of conventional and traditional approaches will become apparent to one of skill in the art, through comparison of such systems with some aspects of the present invention as set forth in the remainder of the present application with reference to the drawings.

BRIEF SUMMARY OF THE INVENTION

A system and/or method is provided for WiFi communication utilizing full spectrum capture, substantially as shown in and/or described in connection with at least one of the figures, as set forth more completely in the claims.

These and other advantages, aspects and novel features of the present invention, as well as details of an illustrated

embodiment thereof, will be more fully understood from the following description and drawings.

BRIEF DESCRIPTION OF SEVERAL VIEWS OF THE DRAWINGS

FIG. **1**A is a block diagram of an exemplary system that comprises WiFi devices that communicate utilizing full spectrum capture, in accordance with an embodiment of the invention.

FIG. **1**B is a high-level block diagram of an exemplary full spectrum capture transceiver device, in accordance with an embodiment of the invention.

FIG. **2** is a block diagram of an exemplary diversity WiFi receiver that utilizes full spectrum capture, in accordance with an embodiment of the invention.

FIG. **3** is a block diagram of an exemplary I/Q RF receive processing chain module of a diversity WiFi receiver that utilizes full spectrum capture, in accordance with an embodiment of the invention.

FIG. **4** is a block diagram of an exemplary baseband processor, in accordance with an embodiment of the invention.

FIG. **5** is a flow chart illustrating exemplary steps for receiving and processing WiFi signals utilizing a full spectrum capture WiFi device (e.g., access point), in accordance with an embodiment of the invention.

FIG. **6** is a flow chart illustrating exemplary steps for receiving and processing WiFi signals utilizing a full spectrum capture WiFi device (e.g., access point), in accordance with an embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

Certain embodiments of the invention may be found in a method and system for WiFi communication utilizing full spectrum capture (FSC). In various aspects of the invention, a single FSC WiFi receiver is operable to utilize full spectrum capture to capture signals over a wide spectrum comprising a plurality of WiFi frequency bands, extract one or more WiFi channels from the captured signals and aggregate a plurality of blocks of WiFi channels to create one or more aggregated WiFi channels. The blocks of WiFi channels may comprise the extracted one or more WiFi channels and/or other WiFi channels. The WiFi frequency bands may comprise, for example, a 2.4 GHz WiFi frequency and a 5 GHz WiFi frequency band. The various aspects and embodiments of the invention are not limited to the 2.4 and 5 GHz frequency bands and may be utilized with other frequency bands without departing from the spirit and/or scope of the invention. A plurality of blocks of the WiFi channels may be aggregated from contiguous blocks of spectrum and/or non-contiguous blocks of spectrum in one or more of the plurality of WiFi frequency bands. Aggregating also comprises capturing and aggregating WiFi channels from a plurality of non-contiguous WiFi frequency bands and keeping the resulting aggregated WiFI channels as separate logical channels. For example, the single FSC WiFi receiver may be operable to capture a plurality of non-contiguous 100 MHz bands and aggregate them as separate logical WiFi channels. The single FSC WiFi receiver is operable to filter out one or more non-WiFi channels from the captured signals to leave only the WiFi channels.

The single FSC WiFi receiver is also operable to assign one or more aggregated WiFi channels to one or more WiFi enabled communication devices. At least a portion of the one or more aggregated WiFi channels may be dynamically assigned to one or more other WiFi enabled communication devices. The single FSC WiFi receiver is further operable to dynamically adjust a bandwidth of one or more processing lanes in order to handle channels of varying bandwidth. A processing lane may comprise a physical channel. The single FSC WiFi receiver may also duty cycle operation of one or more processing lanes within the single receiver. A plurality of processing lanes within the single receiver may be assigned as a broadcast lane for handling high bandwidth traffic. One or more processing lanes within the single FSC WiFi receiver may be assigned as a common lane for handling low bandwidth traffic and/or control traffic. WiFi is short for wireless fidelity and refers to any wireless local area network device, which is based on the IEEE 802.11 standard.

FIG. **1**A is a block diagram of an exemplary system that comprises WiFi devices that communicate utilizing full spectrum capture, in accordance with an embodiment of the invention. Referring to FIG. **1**A, there is shown a wireless local area network (WLAN) **106**, an Internet service provide (ISP) network **108**, a wireless wide area network (WWAN) **110** and the Internet **116**. Also shown are WiFi hotspot networks **112** and **114**. FIG. **1**A also illustrates a plurality of WiFi enabled communication devices comprising tablets **107***a*, **111***a*, **113***a*, **115***a*, Smartphones **107***b*, **111***b*, **113***b*, **115***b* and laptops **107***c*, **111***c*, **113***c*, **115***c*. FIG. **1**A also illustrates a WiFi enabled communication device comprising a broadband router or access point **106***a*.

The tablet **107***a*, the Smartphone **107***b* and the laptop **107***c* may be communicatively coupled to the WLAN **106**. The tablet **107***a*, the Smartphone **107***b* and the laptop **107***c* may be collectively referenced as WiFi enabled communication devices **107**. Each of the WiFi enabled communication devices **107** may comprise a suitable logic, circuitry interfaces and/or code that may be operable to communicate utilizing WiFi. In this regard, each of the WiFi enabled communication devices **107** may comprise a single transceiver device that may be operable to capture signals over a very wide spectrum from different WiFi spectral bands utilizing full spectrum capture.

The tablet **111***a*, the Smartphone **111***b* and the laptop **111***c* may be communicatively coupled to the WWAN **110**. The tablet **111***a*, the Smartphone **111***b* and the laptop **111***c* may be collectively referenced as WiFi enabled communication devices **111**. Each of the WiFi enabled communication devices **111** may comprise a suitable logic, circuitry interfaces and/or code that may be operable to communicate utilizing WiFi. In this regard, each of the WiFi enabled communication devices **111** may comprise a single transceiver device that may be operable to capture signals over a very wide spectrum from different WiFi spectral bands utilizing full spectrum capture.

The tablet **113***a* may comprise a WiFi hotspot **112**. The tablet **113***a*, the Smartphone **113***b* and the laptop **113***c* may be communicatively coupled to the WiFi hotspot **112**. The tablet **113***a*, the Smartphone **113***b* and the laptop **113***c* may be collectively referenced as WiFi enabled communication devices **113**. Each of the WiFi enabled communication devices **113** may comprise a suitable logic, circuitry interfaces and/or code that may be operable to communicate utilizing WiFi. In this regard, each of the WiFi enabled communication devices **113** may comprise a single transceiver device that may be operable to capture signals over a very wide spectrum from different WiFi spectral bands utilizing full spectrum capture. While tablet **113***a* is shown as comprising the WiFi hotspot **112**, any one of the WiFi enabled communication devices **113** (or alternatively an access point or a router) may be used to establish a WiFi hotspot **112**.

The tablet **115***a* may comprise a WiFi hotspot **114**. The tablet **115***a*, the Smartphone **115***b* and the laptop **115***c* may be communicatively coupled to the WiFi hotspot **114**. The tablet **115***a*, the Smartphone **115***b* and the laptop **115***c* may be collectively referenced as WiFi enabled communication devices **115**. Each of the WiFi enabled communication devices **115** may comprise a suitable logic, circuitry interfaces and/or code that may be operable to communicate utilizing WiFi. In this regard, each of the WiFi enabled communication devices **115** may comprise a single transceiver device that may be operable to capture signals over a very wide spectrum from different WiFi spectral bands utilizing full spectrum capture. While tablet **115***a* is shown as comprising the WiFi hotspot **114**, any one of the WiFi enabled communication devices **115** (or alternatively an access point or a router) may be used to establish the WiFi hotspot **114**.

The WLAN **106** may comprise suitable devices and/or interfaces that may be utilized by the plurality of WiFi enabled communication devices **107** to access the Internet **116** via the ISP network **108**. For example, the WLAN **106** may comprise the WiFi enabled broadband access point and/or router **106***a* that is operable to provide broadband connectivity to the ISP **108** and WLAN connectivity to each of the WiFi enabled communication devices **107**. The broadband connectivity may may be provided by, at least in part, cable, satellite or digital subscriber line (DSL) services, for example. The WLAN **106** may also enable the WiFi enabled communication devices **107** to communicate with each other.

The WiFi enabled broadband access point and/or router **106***a* may comprise suitable logic, circuitry, interfaces and/or code that may be operable to provide broadband connectivity to the ISP network **108** and WiFi connectivity to each of the WiFi enabled communication devices **107**. In this regard, the WiFi enabled broadband access point and/or router **106***a* enables each of the tablet **107***a*, the Smartphone **107***b* and the laptop **107***c* to communicate utilizing WiFi to access the services and/or data on the Internet **116** via the ISP network **108** and the WLAN **106**.

The ISP network **108** may comprise suitable devices and/or interfaces that may be coupled to the Internet **116** and provide access to the Internet **116** for various communication devices. The ISP network **108** may comprise, for example, a cable service provider network, a satellite service provider network and a DSL service provider network. In this regard, the ISP network **108** provides access to the Internet **116** for the WiFi enabled communication devices **107**. For example, the ISP network **108** provides access to the services and/or data on the Internet **116** for each of the tablet **107***a*, the Smartphone **107***b* and the laptop **107***c* via the WLAN **106**.

The wireless wide area network **110** may comprise suitable devices and/or interfaces that may be coupled to the Internet **116** and provide access to the Internet **116** for various communication devices. The wireless wide area network **110** may comprise, for example, a cellular service provider (e.g., LTE) and/or a broadband service provider such as, for example, a WiMax (802.16) or WiFi service provider. In this regard, the wireless wide area network **110** provides access to the Internet **116** for the WiFi enabled communication devices **111**. For example, the wireless wide area network **110** provides access to the services and/or data on the Internet **116** for each of the tablet **111***a*, the Smartphone **111***b* and the laptop **111***c*.

The Internet **116** may comprise suitable devices and/or interfaces that may comprise a plurality of servers, which store and serve various data and hosts various Internet services. The ISP **108** may be utilized by the WiFi enabled communication devices **107** to access the Internet services and/or data via the WLAN **106**. The WWAN **110** may be utilized by the WiFi enabled communication devices **111** to access the Internet services and/or data. The Internet **116** is also accessible to the WiFi enabled communication devices **113** via the WiFi hotspot **112** and the WWAN **110**. Similarly, Internet **116** is also accessible to the WiFi enabled communication devices **115** via the WiFi hotspot **114** and the WWAN **110**.

In operation, each of the WiFi enabled communication devices **107**, **111**, **113** and **115** and the WiFi enabled broadband access point and/or router **106***a* are operable to utilize a single WiFi radio to capture WiFi signals over a wide spectrum comprising a plurality of WiFi frequency bands. Instead of having different radios to handle the different WiFi frequency bands, each of the WiFi enabled communication devices **107**, **111**, **113** and **115** and WiFi enabled broadband router **106***a* are operable to utilize a single full spectrum capture receiver that is operable to capture a very large bandwidth comprising the different WiFi frequency bands. In accordance with various embodiments of the invention, the different WiFi frequency bands may be contiguous WiFi frequency bands or non-contiguous WiFi frequency bands. For example, the WiFi signals may occupy a 2.4 GHz band ranging from approximately 2.4-2.9 GHz and a 5 GHz band ranging from approximately 4.9-5.9 GHz. Accordingly, although the WiFi frequency bands are non-contiguous, the single WiFi receiver is utilized to capture the WiFi signals from the corresponding WiFi frequency bands.

FIG. **1**B is a high-level block diagram of an exemplary full spectrum capture transceiver device, in accordance with an embodiment of the invention. Referring to FIG. **1**B, there is shown a full spectrum capture transceiver device **140**. The full spectrum capture transceiver device **140** comprises a plurality of antennas **124***a*, . . . , **124***n*, a baseband processor **142**, a full spectrum capture receiver and transmitter front end **144** and an antenna interface **146**. The full spectrum capture receiver and transmitter front end **144** comprises a full spectrum capture receiver front end **144***a* and a transmitter front end **144***b*.

The plurality of antennas **124***a*, . . . , **124***n* may comprise a plurality of antennas that are utilized to capture a plurality of wireless signals over a wide portion of the spectrum that is allocated for WiFi. The resulting captured plurality of wireless signals are communicated via the antenna interface **146** to the full spectrum capture receiver and transmitter front end **144** for processing. In accordance with an embodiment of the invention, the plurality of antennas **124***a*, . . . , **124***n* may comprise a diversity antenna system, such as, for example, a plurality of phased array antennas. U.S. application Ser. No. 13/857,776, which was filed on Apr. 5, 2013 discloses a plurality of phased array antennas and is hereby incorporated herein by reference in its entirety.

The antenna interface **146** may comprise suitable logic, circuitry, interfaces and/or code that may be operable to control and/or configure operation of the plurality of antennas **124***a*, . . . , **124***n*.

The full spectrum capture receiver front end **144***a* may comprise suitable logic, circuitry, interfaces and/or code that may be operable to receive and process WiFi signals utilizing full spectrum capture. In this regard, the full spectrum capture receiver front end **144***a* may be operable to capture signals over a wide spectrum comprising a plurality of WiFi frequency bands and extract WiFi signals for one or more WiFi channels from the captured signals. The full spectrum capture receiver front end **144***a* may be operable to capture signals over the 2.4 GHz and the 5 GHz WiFi frequency bands and extract one or more WiFi channels.

The transmitter front end **144***b* may comprise suitable logic, circuitry, interfaces and/or code that may be operable to

transmit WiFi signals in accordance with the one or more WLAN protocols. The transmitter front end **144***b* may be operable to synthesize signals over a wide spectrum comprising one or more WiFi freq. bands.

The baseband processor **142** may comprise suitable logic, circuitry, interfaces and/or code that may be operable to provide baseband processing of the WiFi signals that are demodulated by the full spectrum capture receiver front end **144***a*. The baseband processor **142** may also be operable to process information for transmission. The processed information may be communicated to the transmitter front end, where it is modulated and transmitted via the one or more the plurality of antennas **124***a*, . . . , **124***n*. The baseband processor **142** may also be operable to control operation of the full spectrum capture transceiver device **140**. In this regard the baseband processor **142** may be operable to control operation of the plurality of antennas **124***a*, . . . , **124***n*, the antenna interface **146**, and the full spectrum capture receiver front end **144***a* and a transmitter front end **144***b*, which includes the full spectrum capture receiver front end **144***a* and the transmitter front end **144***b*. The baseband processor may be operable to process digitized data for each of the N WiFi channels, which may be handled by the full spectrum capture receiver and transmitter front end **144**.

In operation, the antenna interface **146** may be operable to control and/or configure operation of the plurality of antennas **124***a*, . . . , **124***n* for capturing the signals over a wide spectrum comprising a plurality of WiFi frequency bands.

The full spectrum capture receiver front end **144***a* may comprise suitable logic, circuitry, interfaces and/or code that may be operable to receive and process WiFi signals utilizing full spectrum capture. In this regard, the full spectrum capture receiver front end **144***a* may be operable to capture signals over a wide spectrum comprising a plurality of WiFi frequency bands and extract WIFI signals for one or more WiFi channels from the captured signals. The full spectrum capture receiver front end **144***a* may be operable to concurrently capture WiFi signals over the 2.4 GHz and the 5 GHz WiFi frequency bands and extract one or more WiFi channels from the corresponding captured WiFi signals.

The full spectrum capture transceiver device **140** may be operable to aggregate or bond a plurality of WiFi channels in order to produce a high data rate WiFi channel. In various embodiments of the invention, a single frequency may be assigned or allocated to each WiFi enabled communication device. In this regard, a single FSC WiFi access point (AP) may appear as if it were multiple WiFi access points. The client device, namely, the WiFi enabled communication device, does not need to be modified to benefit from this increased capacity. There may be instances when both the client device and the AP are FSC enabled and are operable to bond a plurality of channels and transmit on the bonded channels. In this regard, transmission may occur in a duty cycle mode utilizing burst mode and sleep mode to optimize power consumption. The FSC WiFi devices may transmit bursts then go to sleep between bursts.

In an exemplary embodiment, a WiFi enabled communication device that is a client device, needs to know the transmit pattern/times of the WiFi AP. The client device is operable to notify the AP that it has data to transmit. The notification may occur in an acknowledgement (ACK) packet. The AP and the client device may be operable to agree on a transmit schedule. In this regard, the AP and client device may agree on when the beacon frames will occur since the beacon frames are utilized for timing. In addition (or alternatively), the AP may transmit beacons at periodic times known to the client device, and the client device synchronizes to receive each beacon frame or some subset of beacon frames (every other, every third, etc.). Alternatively, a beaconless embodiment may be employed. In any event, the AP and client device may operate in accordance with one or more essential or non-essential sections or aspects of the IEEE 802.11 standard.

Aspects of full spectrum capture may be found in U.S. application Ser. No. 13/485,003 filed May 31, 2012, U.S. application Ser. No. 13/336,451 filed on Dec. 23, 2011 and U.S. application Ser. No. 13/607,916 filed Sep. 10, 2012. Each of these applications is hereby incorporated herein by reference in its entirety.

U.S. application Ser. No. 13/356,265, which was filed on Jan. 23, 2012 disclosures operation of an exemplary full spectrum receiver and is hereby incorporated herein by reference in its entirety.

FIG. **2** is a block diagram of an exemplary diversity WiFi receiver that utilizes full spectrum capture, in accordance with an embodiment of the invention. Referring to FIG. **2**, there is shown a diversity WiFi receiver **200**. The diversity WiFi receiver **200** may comprise antennas **202***a*, . . . , **202***n*, antenna interface **204**, variable gain amplifiers **205***a*, **205***b*, multiplexers **206***a*, **206***b*, I/Q RF receive processing chain modules **208***a*, **208***b*, local oscillator generator (LOGEN) **209**, channelizers **210***a*, **210***b*, maximum ratio combiner **212** and a baseband processor **214**. The variable gain amplifier **205***a*, the multiplexer **206***a*, the I/Q RF receive processing chain module **208***a*, and the channelizer **210***a* may be operable to handle the processing of signals received via the antennas **202***a*, . . . , **202***n*. The variable gain amplifier **205***b*, the multiplexer **206***b*, the I/Q RF receive processing chain module **208***b*, and the channelizer **210***b* may be operable to handle the processing of signals received via the antenna **202***b*.

The antennas **202***a*, . . . , **202***n* may comprise suitable logic, circuitry and/or interfaces that are operable to receive WiFi signals. The characteristics of the antennas **202** (e.g., coil) may be such that they may perform filtering functions and, in those instances, transmit and/or receive filters may not be needed.

The antenna interface **204** may comprise suitable logic, circuitry, interfaces and/or code that may be operable to interface with the antennas **202***a*, . . . , **202***n* with the corresponding processing paths in the diversity WiFi receiver **200**.

The variable gain amplifiers **205***a*, **205***b* may comprise suitable logic, circuitry, interfaces and/or code that may be operable to variably adjust a corresponding gain of the input signal from antenna interface **204**. For example, the variable gain amplifiers **205***a* may be operable to amplify and/or buffer the signal received via the antennas **202***a*, . . . , **202***n* from the antenna interface **204**. The variable gain amplifiers **205***a*, **205***b* may operate in different modes that enable capturing of different size bandwidths. For example, the variable gain amplifiers **205***a*, **205***b* may be configured to capture narrowband signals or broadband signals.

The multiplexers **206***a*, **206***b* may comprise suitable logic, circuitry, interfaces and/or code that may be operable to select from among a plurality of n processing RF receive (RX) chains in the I/Q RF receive processing chain modules **208***a*, **208***b*, respectively, where n is an integer. For example, the multiplexers **206***a* may be operable to select which of the plurality of n processing RF receive (RX) chains within the I/Q RF receive processing chain modules **208***a* are to be utilized for demodulation of the signal output from the multiplexer **206***a*. Similarly, the multiplexers **206***b* may be operable to select which of the plurality of n processing RF receive (RX) chains within the I/Q RF receive processing chain modules **208***b* are to be utilized for demodulation of the signal output from the multiplexer **206***b*. The baseband processor **214** may be operable to control which of the plurality of n processing RF receive (RX) chains in the n I/Q RF receive processing chain modules **208***a*, **208***b* may be selected.

The I/Q RF receive processing chain modules **208***a*, **208***b* may comprise suitable logic, circuitry, interfaces and/or code that may be operable to demodulate the signals that are output from the multiplexer **206***a*, **206***b*, respectively. Each of the I/Q RF receive processing chain modules **208***a*, **208***b* may comprise a plurality of n I/Q RF receive processing chains. The baseband processor **214** may be operable to select which of the I/Q RF receive processing chain modules **208***a*, **208***b* are to be utilized to demodulate the signals that are output from the multiplexers **206***a*, **206***b*. For example, the I/Q RF receive processing chain module **208***a* may be utilized to demodulate the signals that are output from the multiplexer **206***a*, while the I/Q RF receive processing chain module **208***b* may be utilized to demodulate the signals that are output from the multiplexer **206***b*.

The full spectrum capture I/Q RF receive (Rx) chain modules **208***a*, **208***b* may comprise suitable logic, circuitry, interfaces and/or code that may be operable to capture signals over a wide spectrum comprising a plurality of WiFi frequency bands and demodulate them. In this regard, a full spectrum capture I/Q RF receive (Rx) chain module may comprise a plurality of receive processing chains that may be operable to demodulate different portions of the signals in the captured WiFi frequency bands. The captured spectrum may comprise WiFi signals and non-WiFi signals. The full spectrum capture I/Q RF receive (Rx) chain module may be operable to discriminate between the WiFi signals and non-WiFi signals and accordingly, filter out the unwanted or undesirable non-WiFi signals. The resulting filtered signals may be digitized and channelized into a corresponding plurality of frequency bins. Additional details of a full spectrum capture I/Q RF receive (Rx) chain module may be found in U.S. Pat. No. 9,125,185, which was filed on Apr. 12, 2013, and is hereby incorporated herein by reference in its entirety.

The LOGEN **209** may comprise suitable logic, circuitry, interfaces and/or code that may be operable to drive one or more oscillators within the I/Q RF receive processing chain modules **208***a*, **208***b*. The LO generator **209** may comprise, for example, one or more crystals, one or more direct digital synthesizers, and/or one or more phase-locked loops.

The channelizers **210***a*, **210***b* may comprise suitable logic, circuitry, interfaces and/or code that may be operable to channelize the demodulated signals that are output from the n I/Q RF receive processing chain **208***a*, **208***b*, respectively. The channelizers **210***a*, **210***b* may be operable to separate each of the corresponding channels into a plurality of frequency bins. The output of the channelizers **210***a*, **210***b* may be combined by a combiner. In accordance with an embodiment of the invention, the channelization may be achieved via one or more digital filtering algorithms and/or other digital signal processing algorithms. Each of the channelizers **210***a*, **210***b* may comprise a plurality of band selection filters that are operable to process the corresponding output from the plurality of n processing RF receive (RX) chains in the n I/Q RF receive processing chain modules **208***a*, **208***b* in order to recover a corresponding one of the a plurality of selected frequency bands or frequency bins. The granularity of the channelizers **210***a*, **210***b* may be programmable. In this regard, the channelizers **210***a*, **210***b* may be programmed to handle channels of varying bandwidth. For example, the channelizers **210***a*, **210***b* may be programmed to handle 20 MHz and/or 40 MHz channels.

The maximum ratio combiner **212** may comprise suitable logic, circuitry, interfaces and/or code that may be operable to combine the channels that are output from the channelizers **210***a*, **210***b*. For example, maximum ratio combiner **212** may be operable to utilize, for example, a coarse FFT processing that employs a low complexity diversity using coarse FFT and subband-wise combining. The coarse FFT processing may optimally combine the signals from a plurality of frequency bins for multiple antennas and accordingly, generate an improved maximum ratio combined (MRC) co-phased signals.

U.S. Pat. No. 8,010,070, (application Ser. No. 12/247,908), which issued on Aug. 30, 2011, discloses exemplary Low-Complexity Diversity Using Coarse FFT and Coarse Sub-band-wise Combining, and is hereby incorporated herein by reference in its entirety.

The maximum ratio combiner **212** may also be operable to utilize channel stacking and/or band stacking of the plurality of frequency bins. In this regard, in one embodiment of the invention, a plurality of WiFi frequency bands or WiFi frequency sub-bands may be stacked utilizing band stacking. In another embodiment of the invention, a plurality of WiFi channels in one or more WiFi frequency bands may be stacked utilizing channel stacking. For example, a plurality of WiFi channels in the 2.4 GHz WiFi band and/or in the 5 GHz WiFi frequency band may be stacked utilizing channel stacking. In other embodiments of the invention, a hybrid or flexible stacking scheme may also be utilized. Additional details regarding stacking may be found in U.S. application Ser. No. 13/762,939, filed on Feb. 8, 2013, which is hereby incorporated herein by reference in its entirety.

The baseband processor **214** may comprise suitable logic, circuitry, interfaces and/or code that may be operable to provide baseband processing on the channels that are generated from the maximum ratio combiner **212**. The baseband processor **214** may also be operable to function as a controller for the diversity WiFi receiver **200**. In this regard, the baseband processor **214** may be operable to control, configure and/or manage operation of one or more of the antenna interface **204**, the variable gain amplifiers **205***a*, **205***b*, the multiplexers **206***a*, **206***b*, the I/Q RF receive processing chain modules **208***a*, **208***b*, the local oscillator generator (LOGEN) **209**, the channelizers **210***a*, **210***b*, and the maximum ratio combiner **212**. The baseband processor **214** may be operable to control, configure and/or manage operation of one or more of the components in the I/Q RF receive processing chain modules **208***a*, **208***b* such as mixers, filters and/or analog to digital controllers (ADCs).

Although the maximum ratio combiner **212** and the baseband processor **214** are illustrated as separate entities, the maximum ratio combiner **212** may be integrated as part of the baseband processor **214**.

Although only two antennas **202***a*, . . . , **202***n* are shown for diversity, the invention is not limited in this regard. Accordingly, more than two antennas may be utilized without departing from the spirit and scope of the invention. The addition of more than two antennas utilizes additional processing paths in the diversity WiFi receiver **200**.

Although a diversity WiFi receiver is illustrated, the invention is not limited to the use of the diversity WiFi receiver. Accordingly, various embodiments of the invention may utilize a non-diversity receiver without departing from the spirit and scope of the various embodiments of the invention.

FIG. **3** is a block diagram of an exemplary I/Q RF receive processing chain module of a diversity WiFi receiver that utilizes full spectrum capture, in accordance with an embodiment of the invention. Referring to FIG. **3**, there is shown an I/Q RF receive processing chain module **300**. The I/Q RF receive processing chain module **300** comprises a plurality of n I/Q RF receive processing chains, where n is an integer. The plurality of n I/Q RF receive processing chains are referenced as $\mathbf{306}_1$, $\mathbf{306}_2$, . . . , $\mathbf{306}_n$. Each of the n I/Q RF receive processing chains $\mathbf{306}_1$, $\mathbf{306}_2$, . . . , $\mathbf{306}_n$ are substantially similar. Each of the processing chains may also be referred to as a physical channel or a processing lane.

The I/Q RF receive processing chains $\mathbf{306}_1$ comprises an in-phase (I) path and a quadrature (Q) path. The in-phase path of the I/Q RF receive processing chains $\mathbf{306}_1$ comprises a mixer $\mathbf{308}_I$, a filter $\mathbf{310}_I$, and an analog to digital converter (ADC) $\mathbf{312}_I$. The quadrature path of the I/Q RF receive processing chains $\mathbf{306}_1$ comprises a mixer $\mathbf{308}_Q$, a filter $\mathbf{310}_Q$, and an analog to digital converter (ADC) $\mathbf{312}_Q$.

Each of the mixers $\mathbf{308}_I$, $\mathbf{308}_Q$ may comprise suitable logic, circuitry, interfaces and/or code that may be operable to mix the corresponding signal $\mathbf{302}_1$ with a local oscillator signal (not shown) to generate the signal $\mathbf{309}_I$, $\mathbf{309}_Q$, respectively. The mixers $\mathbf{308}_I$, $\mathbf{308}_Q$ are operable to mix the signal $\mathbf{302}_1$ with a pair of in-phase (I) and quadrature (Q) local oscillator signals, respectively, to generate the corresponding pair of in-phase and quadrature signals $\mathbf{309}_I$, $\mathbf{309}_Q$.

In some embodiments of the invention, the mixers in each of the I/Q RF receive processing chains may be operable to function with similar characteristics, and, in other embodiments of the invention, the mixers in each of the I/Q RF receive processing chains may be operable to function with different characteristics. For example, the mixers $\mathbf{308}_I$, $\mathbf{308}_Q$ may be configured to operate with a higher bandwidth than the mixers (not shown), which may be within the I/Q RF receive processing chain $\mathbf{306}_2$. Similarly, the mixers (not shown), which may be within the I/Q RF receive processing chain $\mathbf{306}_2$ may be configured to operate with a higher bandwidth than the mixers (not shown), which may be within the I/Q RF receive processing chain $\mathbf{306}_n$, and the mixers $\mathbf{308}_I$, $\mathbf{308}_Q$, which may be within the I/Q RF receive processing chain $\mathbf{306}_n$.

The phase and/or frequency of the local oscillator signals (not shown), which are input to the mixers in each of the I/Q RF receive processing chains $\mathbf{306}_1$, $\mathbf{306}_2$, . . . , $\mathbf{306}_n$, may be controlled via one or more signals from the baseband processor **214**, which is illustrated in FIG. **2**. In accordance with various embodiments of the invention, the phase and/or frequency of the local oscillator signals, which are input to the mixers in each of the I/Q RF receive processing chains $\mathbf{306}_1$, $\mathbf{306}_2$, . . . , $\mathbf{306}_n$, may be controlled by the baseband processor **214** based on which one or more WiFi channels and/or WiFi frequency bands are to be captured by the diversity WiFi receiver **200**. The phase and/or frequency of the local oscillator signals, which are input to the mixers in each of the I/Q RF receive processing chains $\mathbf{306}_1$, $\mathbf{306}_2$, . . . , $\mathbf{306}_n$, may be generated from the LOGEN **209**, which is illustrated in FIG. **2**.

The filters in each of the I/Q RF receive processing chains $\mathbf{306}_1$, $\mathbf{306}_2$, . . . , $\mathbf{306}_n$ may comprise suitable logic, circuitry, interfaces and/or code that may be operable to filter out undesired frequencies/channels from the corresponding signals that are output from the oscillators in each of the I/Q RF receive processing chains $\mathbf{306}_1$, $\mathbf{306}_2$, . . . , $\mathbf{306}_n$. For example, each of the filters $\mathbf{310}_I$, $\mathbf{310}_Q$ in the I/Q RF receive processing chains $\mathbf{306}_1$ may be operable to filter out undesired frequencies from the signals $\mathbf{309}_I$, $\mathbf{309}_Q$ to generate the corresponding analog signals $\mathbf{311}_I$, $\mathbf{311}_Q$.

In some embodiments of the invention, the filters in each of the I/Q RF receive processing chains $\mathbf{306}_1$, $\mathbf{306}_2$, . . . , $\mathbf{306}_n$ may be operable to function with similar characteristics, and, in other embodiments of the invention, the filters in each of the I/Q RF receive processing chains 306_1, 306_2, . . . , 306_n may be operable to function with different characteristics. For example, the filters 310_I, 310_Q, which are within the I/Q RF receive processing chains 306_1, may be configured to operate with a higher bandwidth than the filters (not shown), which may be within the I/Q RF receive processing chain 306_2. Similarly, the filters (not shown), which may be within the I/Q RF receive processing chain 306_2 may be configured to operate with a higher bandwidth than the mixers (not shown), which may be within the I/Q RF receive processing chain 306_n, and the mixers 310_I, 310_Q, which may be within the I/Q RF receive processing chain 306_n.

The ADCs in each of the I/Q RF receive processing chains 306_1, 306_2, . . . , 306_n may comprise suitable logic, circuitry, interfaces and/or code that may be operable to convert the analog signals from the corresponding signals that are output from the filters in each of the I/Q RF receive processing chains 306_1, 306_2, . . . , 306_n. For example, each of the ADC 312_I, 312_Q in the I/Q RF receive processing chains 306_1 may be operable to convert the analog signals 311_I, 311_Q to the corresponding digital signals 313_I, 313_Q. The ADCs may be preceded by a frequency conversion step and filtering to shift a higher frequency band to a lower frequency or baseband, where it is easier to design wideband data converters.

In some embodiments of the invention, the ADCs in each of the I/Q RF receive processing chains 306_1, 306_2, . . . , 306_n may be operable to function with similar characteristics, and, in other embodiments of the invention, the ADCs in each of the I/Q RF receive processing chains 306_1, 306_2, . . . , 306_n may be operable to function with different characteristics. For example, the ADCs 312_I, 312_Q, which are within the I/Q RF receive processing chains 306_1, may be configured to operate with a higher bandwidth than the ADCs (not shown), which may be within the I/Q RF receive processing chain 306_2. Similarly, the ADCs (not shown), which may be within the I/Q RF receive processing chain 306_2 may be configured to operate with a higher bandwidth than the ADCs (not shown), which may be within the I/Q RF receive processing chain 306_n, and the ADC 310_I, 310_Q, which may be within the I/Q RF receive processing chain 306_n.

In operation, the diversity WiFi receiver **200** may be configured to capture a specified number of WiFi channels. In this regard, the baseband processor **214** may be operable to configure the multiplexer that feeds the I/Q RF receive processing chains 306_1, 306_2, . . . , 306_n to select and enable a corresponding number of the I/Q RF receive processing chains 306_1, 306_2, . . . , 306_n, which are to be utilized to handle reception and demodulation of the specified number of WiFi channels. In some embodiments of the invention, only those I/Q RF receive processing chains 306_1, 306_2, . . . , 306_n which are selected by the processor are powered and any remaining ones of the I/Q RF receive processing chains 306_1, 306_2, . . . , 306_n that are not selected are powered down.

FIG. **4** is a block diagram of an exemplary baseband processor, in accordance with an embodiment of the invention. Referring to FIG. **4**, there is shown a baseband processor **400**. The baseband processor **400** may comprise a MRC module **402**, a beamforming module **406**, a MIMO module **408**, a demodulator module **410**, a decoder **412**, a beamforming module **416**, a MIMO module **418**, a modulator module **420**, a encoder **422**, a processor **424** and memory **426**. The baseband processor **400** may be substantially similar to the baseband processor **200**, which is illustrated and described with respect to FIG. **2**. The MRC module **402**, the beamforming module **406**, the MIMO module **408**, the demodulator module **410** and the decoder **412** may comprise a demodulation path **413**. The beamforming module **416**, the MIMO module **418**, the modulator module **420**, the encoder **422** may comprise a modulation path **423**.

The MRC module **402** may comprise suitable logic, circuitry, interfaces and/or code that may be operable to channels that are output from the channelizers **210***a*, **210***b*. For example, maximum ratio combiner **212** may be operable to utilize, for example, a coarse FFT processing that employs a low complexity diversity using coarse FFT and subband-wise combining. The coarse FFT processing may optimally combine the signals from a plurality of frequency bins for multiple antennas and accordingly, generate an improved maximum ratio combined (MRC) co-phased signals. The maximum ratio combiner **402** may also be operable to utilize channel stacking and/or band stacking for the plurality of frequency bins.

The beamforming module **406** may comprise suitable logic, circuitry, interfaces and/or code that may be operable to utilize one or more beamforming algorithms to process signals from the plurality of antennas **202***a*, . . . , **202***n*.

The MIMO module **408** may comprise suitable logic, circuitry, interfaces and/or code that may be operable to utilize one or more MIMO algorithms to process signals from the beamforming module **406** for plurality of antennas **202***a*, . . . , **202***n*.

The demodulator module **410** may comprise suitable logic, circuitry, interfaces and/or code that may be operable to demodulate the signals from the MIMO module **408**.

The decoder **412** may comprise suitable logic, circuitry, interfaces and/or code that may be operable to decode the resulting demodulated signals from the demodulator module **410**.

The encoder **422** may comprise suitable logic, circuitry, interfaces and/or code that may be operable to encode data to be transmitted utilizing one or more encoding algorithms.

The modulator module **420** may comprise suitable logic, circuitry, interfaces and/or code that may be operable to may be utilized to modulate the resulting encoded output from the encoder **422**.

The MIMO module **418** may comprise suitable logic, circuitry, interfaces and/or code that may be operable to utilize one or more MIMO algorithms (e.g., as defined or supported by 802.11n or 802.11ac) to process signals for transmission via the plurality of antennas **202***a*, . . . , **202***n*.

The beamforming module **416** may comprise suitable logic, circuitry, interfaces and/or code that may be operable to utilize one or more beamforming algorithms to process signals from the MIMO module **418** for transmission via the plurality of antennas **202***a*, . . . , **202***n*.

The processor **424** may comprise suitable logic, circuitry, interfaces and/or code that may be operable to control operation of the FSC WiFi receiver **200**. In this regard, the processor **424** may be operable to control the components within the FSC receiver module and the baseband processor.

The memory **426** may comprise suitable logic, circuitry, interfaces and/or code that may be operable to store operating code, operating data and configuration settings. The memory **426** may be operable to store information that may be utilized to control operation of one or more of the components in the FSC receiver module and the baseband processor of the FSC WiFi receiver.

In operation, the signals received by the full spectrum capture transceiver **140** are channelized and the MIMO module **408** is operable to synthesize MIMO channels from all the captured WiFi channels. The architecture of the full spectrum capture transceiver **140** enables, for example, one of the WiFi channels to be pulled out and all of the bandwidth for those particular WiFi channels may be assigned to a particular WiFi enabled communication device. In other words, in instances where there are a plurality of WiFi enabled communication devices, the full spectrum capture transceiver **140** may be operable to assign each of the plurality of WiFi enabled communication devices its own dedicated WiFi channel. In this regard, there is no need for a plurality of WiFi enabled communication devices to share a particular WiFi AP channel. The number of WiFi enabled communication devices to which the channels may be assigned may be dependent on or limited by the number of demodulators that are available, for example, in the full spectrum capture transceiver **140**.

In accordance with an embodiment of the invention, based on the architecture of the full spectrum capture transceiver **140**, in order to double the capacity, twice the number of channels may be channelized by the full spectrum capture transceiver **140** and assigned to the client WiFi enabled communication devices. Accordingly, there is no need to modify the architecture of the client WiFi enabled communication devices. In other words, only the access point/router needs to be modified. The full spectrum capture transceiver **140** provides a flexible and scalable architecture to increase capacity without having to modify the client WiFi enabled communication devices or having to add complexity to the Access point and/or router.

In accordance with various embodiments of the invention, certain traffic may be assigned to certain channels based on various criteria. For example, a user of a client WiFi enabled communication device that is surfing the Web may be assigned to one channel, and another user of a client WiFi enabled communication device that may be a watching HD video content may be assigned to another channel, and so on. Different bandwidth channels may be assigned to different client WiFi enabled communication devices based on bandwidth requirements. In conventional WiFi APs, in order for a user to get dedicated WiFi channels, that user would have to upgrade the AP to an 802.11ac compliant WiFi AP. However, the full spectrum capture transceiver **140** is operable to provide dedicated channel usage and channels may be assigned based on the type of traffic or class of traffic that is being handled. In effect, the full spectrum capture transceiver **140** is operable to provide 802.11 ac capabilities without the need to actually utilize an 802.11ac communication device. The full spectrum capture transceiver **140** allows adaptive and dynamic sensing of the channels to determine which ones are being utilized or are unusable or impaired due to fading, interference or noise, and those channels can be avoided or marked as bad. Those channels that are usable or are not impaired and may therefore be selected and allocated for use. Accordingly, the full spectrum capture transceiver **140** may be referred to as a WiFi Turbocharger.

One major advantage of utilizing full spectrum capture with WiFi is that only the APs need to be upgraded and not the client WiFi enabled communication devices. This is a win situation for consumers in that they do not need to upgrade their WiFi enabled laptops or other client WiFi enabled communication devices to take full advantage of the various features and functions provided by FSC with WiFi. Accordingly, network providers may upgrade the network infrastructure without having to worry about end-users upgrading their WiFi enabled communication devices.

The use of multiple WiFi channels by the full spectrum capture transceiver **140** may provide power savings. Duty cycling across a plurality of WiFi channels may provide power savings as opposed to sending a significant amount of data across a single WiFi channel. The full spectrum capture transceiver **140** may be operable to transmit data in a burst mode, after which, the full spectrum capture transceiver **140** goes to sleep. The sleep and wake modes may be dependent on, for example, WiFi beacon timing. The WiFi enabled communication devices may burst data, for example, in a round-robin time division manner across a plurality of WiFi channels assigned by the full spectrum capture transceiver **140**. The full spectrum capture transceiver **140** may configure and assign multiple channels and the WiFi enabled communication devices may be operable to burst data across the assigned WiFi channels in a synchronous manner. The data may be burst across one or more WiFi channels. The WiFi receivers may be shut down or enter a low power mode in instances when the WiFi transmitter is not bursting data or when the WiFi receivers may be consuming content that was previously received in a burst. In one example, a WiFi enabled communication device's transceiver circuit may enter a low power mode when it is not communicating video and the device's transceiver circuit may enter a sleep mode when it is consuming received content. In another example, the WiFi enabled communication device may receive 2 seconds worth of video and send acknowledgements and then shut down the RF front-end circuits in the FSC WiFi receiver when the FSC WiFi receiver is consuming the 2 seconds worth of video. The full spectrum capture WiFi AP and/or router may be operable to store timing offset information for each of the WiFi enabled communication devices in order to provide multi-channel synchronicity, which enables seamless switching between channels.

FIG. **5** is a flow chart illustrating exemplary steps for receiving and processing WiFi signals utilizing a full spectrum capture WiFi device (e.g., access point), in accordance with an embodiment of the invention. Referring to FIG. **5**, there is shown exemplary steps **502** through **510**. In step **502**, an FSC WiFi access point is configured to capture spectrum in one or more WiFi frequency bands. In step **504**, the FSC WIFI access point captures the spectrum comprising a plurality of WiFi channels. In step **506**, the WiFi access point discriminates between the WiFi signals and non-WiFi signals in the captured spectrum and discards non-WiFi signals. In step **508**, the FSC WiFi access point is operable to aggregate a plurality of the WiFi channels, which correspond to the WiFi signals, and/or one or more other WiFi channels to generate an aggregated WiFi channel. In step **510**, the FSC WiFi access point may be operable to assign one or more users to at least a portion of the aggregated WiFi channel.

FIG. **6** is a flow chart illustrating exemplary steps for receiving and processing WiFi signals utilizing a full spectrum capture WiFi device (e.g., access point), in accordance with an embodiment of the invention. Referring to FIG. **6**, there is shown exemplary steps **604** through **612**. In step **604**, a FSC WIFI access point captures the spectrum comprising a plurality of WiFi channels. In step **606**, the WiFi access point filters the captured spectrum and keeps the WiFi signals and discards the non-WiFi signals. In step **608**, the FSC WiFi access point is operable to aggregate a plurality of the WiFi channels corresponding to the WiFi signals to generate plurality of aggregated WiFi channels. In step **610**, the FSC WiFi access point may be operable to assign each of the plurality of aggregated WiFi channels as a dedicated WiFi channel to a corresponding one of a plurality of WiFi enabled communication devices. In step **612**, FSC WiFi access point may be operable to Burst data to each of the plurality of WiFi enabled communication devices over their corresponding dedicated WiFi channel.

While the discussion with respect to FIG. **5** and FIG. **6** specifically reference an access point, the functionality described can be employed by any WiFi enabled communication device (such as, for example, a client device providing WiFi connectivity to other client devices).

In accordance with various embodiments of the invention, a single FSC WiFi receiver **140** is operable to utilize full spectrum capture to capture signals over a wide spectrum comprising a plurality of WiFi frequency bands, extract one or more WiFi channels from the captured signals and aggregate a plurality of blocks of the WiFi channels to create one or more aggregated WiFi channels. The blocks of WiFi channels may comprise the extracted one or more WiFi channels and/or other WiFi channels. The WiFi frequency bands may comprise, for example, a 2.4 GHz WiFi frequency band and a 5 GHz WiFi frequency band. The various aspects and embodiments of the invention are not limited to the 2.4 and 5 GHz frequency bands and may be utilized with other frequency bands without departing from the spirit and/or scope of the invention. The single FSC WiFi receiver **140** is operable to aggregate a plurality of blocks of the WiFi channels from contiguous blocks of spectrum and/or non-contiguous blocks of spectrum in one or more of the plurality of WiFi frequency bands, for example, 2.4 GHz and 5 GHz. Aggregating also comprises capturing and aggregating WiFi channels from a plurality of non-contiguous WiFi frequency bands and keeping the resulting aggregated WiFI channels as separate logical channels. For example, the single FSC WiFi receiver may be operable to capture a plurality of non-contiguous 100 MHz bands and aggregate them as separate logical WiFi channels. The single FSC WiFi receiver is operable to filter out one or more non-WiFi channels from the captured signals to leave only the WiFi channels. The single FSC WiFi receiver is operable to assign one or more aggregated WiFi channels to one or more WiFi enabled communication devices. At least a portion of the one or more aggregated WiFi channels may be dynamically assigned to one or more other WiFi enabled communication devices.

The single FSC WiFi receiver **140** is also operable to dynamically adjust a bandwidth of one or more processing lanes in order to handle channels of varying bandwidth. The single FSC WiFi receiver **140** may also duty cycle operation of one or more processing lanes within the single receiver. A plurality of processing lanes within the single receiver may be assigned as a broadcast lane for handling high bandwidth traffic. One or more processing lanes within the single FSC WiFi receiver **140** may be assigned as a common lane for handling low bandwidth traffic and/or control traffic.

As utilized herein the terms "circuits" and "circuitry" refer to physical electronic components (i.e. hardware) and any software and/or firmware ("code") which may configure the hardware, be executed by the hardware, and or otherwise be associated with the hardware. As used herein, for example, a particular processor and memory may comprise a first "circuit" when executing a first one or more lines of code and may comprise a second "circuit" when executing a second one or more lines of code. As utilized herein, "and/or" means any one or more of the items in the list joined by "and/or". As an example, "x and/or y" means any element of the three-element set {(x), (y), (x, y)}. As another example, "x, y, and/or z" means any element of the seven-element set {(x), (y), (z), (x, y), (x, z), (y, z), (x, y, z)}. As utilized herein, the term "exemplary" means serving as a non-limiting example, instance, or illustration. As utilized herein, the terms "e.g.," and "for example" set off lists of one or more non-limiting examples, instances, or illustrations. As utilized herein, circuitry is "operable" to perform a function whenever the circuitry comprises the necessary hardware and code (if any is necessary) to perform the function, regardless of whether performance of the function is disabled, or not enabled, by some user-configurable setting.

Other embodiments of the invention may provide a computer readable device and/or a non-transitory computer readable medium, and/or a machine readable device and/or a non-transitory machine readable medium, having stored thereon, a machine code and/or a computer program having at least one code section executable by a machine and/or a computer, thereby causing the machine and/or computer to perform the steps as described herein for WiFi communication utilizing full spectrum capture.

Accordingly, the present invention may be realized in hardware, software, or a combination of hardware and software. The present invention may be realized in a centralized fashion in at least one computer system, or in a distributed fashion where different elements are spread across several interconnected computer systems. Any kind of computer system or other apparatus adapted for carrying out the methods described herein is suited. A typical combination of hardware and software may be a general-purpose computer system with a computer program that, when being loaded and executed, controls the computer system such that it carries out the methods described herein.

The present invention may also be embedded in a computer program product, which comprises all the features enabling the implementation of the methods described herein, and which when loaded in a computer system is able to carry out these methods. Computer program in the present context means any expression, in any language, code or notation, of a set of instructions intended to cause a system having an information processing capability to perform a particular function either directly or after either or both of the following: a) conversion to another language, code or notation; b) reproduction in a different material form.

While the present invention has been described with reference to certain embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted without departing from the scope of the present invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the present invention without departing from its scope. Therefore, it is intended that the present invention not be limited to the particular embodiment disclosed, but that the present invention will include all embodiments falling within the scope of the appended claims.

What is claimed is:

1. A method, comprising:

in a single receiver:

capturing signals over a wide spectrum comprising a plurality of WiFi frequency bands;

extracting a plurality of WiFi channels from said captured signals;

concurrently digitizing, via one or more processing lanes of said single receiver, said plurality of WiFi channels, wherein each of said one or more processing lanes comprises a mixer and one or more analog-to-digital converters;

aggregating two or more of said plurality of WiFi channels to create one or more aggregated WiFi channels.

2. The method according to claim **1**, wherein said plurality of WiFi frequency bands comprise a 2.4 GHz WiFi frequency band and a 5 GHz WiFi frequency band.

3. The method according to claim **1**, comprising aggregating said plurality of WiFi channels from contiguous blocks of spectrum and/or non-contiguous blocks of spectrum in one of said plurality of WiFi frequency bands.

4. The method according to claim **1**, comprising aggregating said plurality of WiFi channels from contiguous blocks of spectrum and/or non-contiguous blocks of spectrum in another one of said plurality of WiFi frequency bands.

5. The method according to claim **1**, comprising duty cycling operation of said one or more processing lanes within said single receiver.

6. The method according to claim **1**, comprising filtering out one or more non-WiFi channels from said captured signals.

7. The method according to claim **1**, comprising assigning said one or more aggregated WiFi channels to one or more WiFi enabled communication devices.

8. The method according to claim **7**, comprising dynamically reassigning at least a portion of said one or more aggregated WiFi channels to one or more other WiFi enabled communication devices.

9. The method according to claim **1**, comprising dynamically adjusting a bandwidth of said one or more processing lanes within said single receiver to handle channels of varying bandwidth.

10. The method according to claim **1**, wherein said single receiver comprises a plurality of said processing lanes and comprising:

assigning two or more of said plurality of processing lanes within said single receiver as a broadcast lane for handling high bandwidth traffic; and

assigning one or more of said plurality of processing lanes within said single receiver as a common lane for handling low bandwidth traffic and/or control traffic.

11. A system, comprising:

one or more circuits for use in a single receiver, said one or more circuits being operable to:

capture signals over a wide spectrum comprising a plurality of WiFi frequency bands;

extract a plurality of WiFi channels from said captured signals;

concurrently digitize, via one or more processing lanes of said single receiver, said plurality of WiFi channels, wherein each of said one or more processing lanes comprises a mixer and one or more analog-to-digital converters; and

aggregate two or more of said plurality of WiFi channels to create one or more aggregated WiFi channels.

12. The system according to claim **11**, wherein said plurality of WiFi frequency bands comprises a 2.4 GHz WiFi frequency band and a 5 GHz WiFi frequency band.

13. The system according to claim **11**, wherein said one or more circuits are operable to aggregate said plurality of WiFi channels from contiguous blocks of spectrum and/or non-contiguous blocks of spectrum in one of said plurality of WiFi frequency bands.

14. The system according to claim **11**, wherein said one or more circuits are operable to aggregate said plurality of WiFi channels from contiguous blocks of spectrum and/or non-contiguous blocks of spectrum in another one of said plurality of WiFi frequency bands.

15. The system according to claim **11**, wherein said one or more circuits are operable to duty cycle operation of said one or more processing lanes within said single receiver.

16. The system according to claim **11**, wherein said one or more circuits are operable to filter out one or more non-WiFi channels from said captured signals.

17. The system according to claim **11**, wherein said one or more circuits are operable to assign said one or more aggregated WiFi channels to one or more WiFi enabled communication devices.

18. The system according to claim **17**, wherein said one or more circuits are operable to dynamically reassign at least a portion of said one or more aggregated WiFi channels to one or more other WiFi enabled communication devices.

19. The system according to claim **11**, wherein said one or more circuits are operable to dynamically adjust a bandwidth of said one or more processing lanes within said single receiver to handle channels of varying bandwidth.

20. The system according to claim **11**, wherein said one or more circuits comprise a plurality of said processing lanes and are operable to:

assign two or more of said plurality of processing lanes within said single receiver as a broadcast lane for handling high bandwidth traffic; and

assign one or more of said plurality of processing lanes within said single receiver as a common lane for handling low bandwidth traffic and/or control traffic.

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